MINISTRY OF POWER

EXPLOSION AT BICKERSHAW Nos. 1, 2, 3 and 4 COLLIERY, LANCASHIRE

REPORT

On the causes of, and circumstances attending, the Explosion which occurred at Bickershaw Nos. 1, 2, 3 and 4 Colliery, Lancashire, on 10th October, 1959

BY

R. H. CLOUGH, O.B.E.

H.M. Divisional Inspector of Mines and Quarries

Presented to Parliament by the Minister of Power
by Command of Her Majesty
April 1960

LONDON
HER MAJESTY'S STATIONERY OFFICE
TWO SHILLINGS NET

Cmnd. 1000

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TABLE OF CONTENTS

	Page
INTRODUCTION	3
DESCRIPTION OF THE COLLIERY	3
THE PLODDER SEAM	4
EVENTS BEFORE THE SEALING OF NO. 9 FACE	5
THE EXPLOSION	7
INVESTIGATION	9
RECOMMENDATIONS	15
ACKNOWLEDGMENTS	16

APPENDIX

1. List of casualties 16

PLAN I—Plan of Plodder Seam showing scene of Explosion. (In pocket at back of report.)

Report on the causes of, and circumstances attending, the explosion which occurred at Bickershaw Nos. 1, 2, 3 and 4 Colliery in the county of Lancaster on 10th October, 1959

Britannic Building,
Fountain Street,
Manchester, 2.
26th February, 1960.

The Right Honourable Richard Wood, M.P.,
Minister of Power.

SIR,

INTRODUCTION

(1) In accordance with your direction given under the terms of Section 121 of the Mines and Quarries Act, 1954, I beg to report on the explosion which occurred behind stoppings in the Plodder Seam at Bickershaw Colliery on the afternoon shift of the 10th October, 1959, when five persons were killed. Another man suffered shock and slight injury but soon recovered.

(2) On 12th November, 1959, Colonel R. M. Barlow, H.M. Coroner of the County of Lancaster, Bury District, resumed his inquest on the bodies of the five men. A verdict of "Misadventure" was recorded in each case, and medical evidence showed that all five men had died from carbon monoxide gas poisoning. I take this opportunity of expressing my thanks to H.M. Coroner for his courteous assistance to myself and other parties in the examination of witnesses.

(3) Owing to the circumstances immediately following the explosion which demanded the isolation by further stoppings of the affected
has been no physical examination of the scene of the explosion after rescue operations were completed, other than a necessarily brief examination made by men wearing self contained breathing apparatus.

DESCRIPTION OF THE COLLIERY

(4) Bickershaw Colliery is at Leigh, Lancashire, and is one unit of the No. 3 Group of the No. 2 (Wigan) Area of the North Western Division of the National Coal Board. The following Area officials are instructed under Section I of the Mines and Quarries Act, 1954, for the purpose of fulfilling the responsibilities of the National Coal Board under the Act:

Area General Manager	Mr. H. E. Clegg
Area Production Manager	Mr. E. Small, M.B.E.
Group Manager	Mr. J. McGann

(5) Bickershaw Colliery is served by four shafts, numbered 1, 2, 3 and 4. Numbers 1 and 2 Shafts serve one part of the mine, and Nos. 3 and 4 the other.

Both parts have separate systems of ventilation, but are accessible to each other below ground. Under the terms of Section 168 of the Mines and Quarries Act, 1954, the two parts are regarded as separate mines, each with its own manager. The manager for Nos. 1 and 2 is Mr. A. H. Miller, and Mr. J. M. Lawson is the manager of Nos. 3 and 4. A statutory notice of approval has been issued setting out the respective spheres of responsibility of these two managers. In particular all the surface works are the responsibility of Mr. Lawson. He has an assistant manager Mr. T. W. Allison, but who does not shoulder any direct responsibility under the Act.

(6) The circumstances of the explosion on 10th October, 1959, are related only to the Nos. 3 and 4 workings, and in particular to the Plodder Seam.

THE PLODDER SEAM

(7) The Plodder (sometimes known as the Ravine) Seam has a worked section at Bickershaw of about 6 feet. It lies immediately over the Haigh Yard Seam. These two seams, and their associated dirt bands, have an overall thickness of 18 feet. The Plodder Seam is well known in the coalfields as one liable to spontaneous combustion, particularly in the Wigan and Leigh areas, and there is at Bickershaw a long experience of trouble from this cause. With seams so close together as the Plodder and Haigh Yard, spontaneous heating can occur in the individual working of either, since the extraction of any one is bound to expose, in part, the other. The risk of self-heating is often associated with such thick seams in close proximity.

(8) At Bickershaw Colliery the Plodder Seam was developed in a south easterly direction on a line of almost full dip at an average gradient of 1 in 7. By 1959 a large amount of extraction had taken place and large goaf areas formed. Progress was by a developing face to the dip with wing faces advancing east and west respectively.

(9) At the end of August, 1959, only two longwall faces were working in the Plodder Seam; Nos. 1 and 2 Dip Faces with a combined output of about 550 tons per day. The only other accessible face was the No. 9 East, which ceased production on 14th August, 1959 (see Plan). It was still being ventilated, and a small team of men were engaged in salvaging material. Of the three open faces, No. 2 was ventilated by an air current separate from the others, while another split of air was conducted, first along No. 1 Dip Face after which it passed into the Main Level of the No. 9 East Face, where it was augmented by some intake leakage from the No. 4 Brow. The quantity of air ventilating No. 9 East, when last measured on 21st August, 1959, was 14,700 cubic feet per minute, and the average percentage of inflammable gas in the return airway from this face as determined at a point 10 yards from the face on No. 9 East Top Level was 0·95 per centum. Of this gas some was contributed by No. 2 Dip Face, the air on which normally contained about 0·3 per centum in a quantity of 12,500 cubic feet per minute. A rough estimation suggests an average emission of firedamp on No. 9 Face alone of the order of 100 cubic feet per minute.

(10) The No. 9 Face had advanced about 800 yards alongside the goaf of the old abandoned No. 8 Face to the rise side, keeping contact with this goaf as it progressed, while the No. 9 right hand or dip side was forming a coal rib. Both Main and Top Levels of No. 9 Face were supported by steel arches.

The general dimensions of the Main Level were 13 feet wide hy 10 feet high: those of the Top Level, 9 feet wide by 7 feet high at the face, but, owing to severe crush probably associated with the nearness of the No. 8 goaf, it was reduced in size to about 3½ feet by 4½ feet for about 200 yards of its total length.

(11) The No. 8 East Face, when working, was 160 yards in length. It ceased production on 9th August, 1957, and stoppings were put in some three months later. These stoppings were later extended by the stowing of waste dirt and by October, 1959, the No. 8 Top Level stopping was 150 yards long, and the No. 8 Main Level stopping, 100 yards long.

EVENTS BEFORE THE SEALING OF NO. 9 FACE

(12) During the morning of Sunday, the 4th October, a deputy, F. Hodgson, accompanied by a workman as a travelling companion, was making an ordinary week-end inspection of No. 9 Face. These two men entered the face by the Main Level (intake), travelled up the face, and then out by the Top Level (return). Immediately on leaving the face at the Top Level, Hodgson noticed a smell of " heating " when he was about 3 yards outbye the face ripping lip. He also recognised some haze and " sweating " on the roof at the higher side, adjoining the abandoned No. 8 Face. These findings were communicated to the manager who subsequently made an examination of the place accompanied by the assistant manager, Mr. Allison. Mr. Lawson decided that it would be practicable to deal with the heating by excavating or " digging out " the pack, and steps were taken at once to do this.

(13) During that Sunday afternoon, and the two following shifts, men were engaged in removing the packing, and from the evidence of those engaged on this work, it is possible that this excavation eventually penetrated for some few feet at least, into what was originally the right hand pack of the abandoned No. 8 Face. About the heating there was no doubt: the packing material taken out was hot and had to be quenched with water before being cast aside, and at one time or another incandescence was observed by Mr. Allison and by one of the deputies immediately in supervision.

(14) By the end of the morning shift of Monday, the 5th October, it was decided that all the heated material had been removed and quenched and steps were then taken to restore the roadway side by filling the excavation with sand, faced with a sand bag wall. All this was completed by the end of the morning shift on the 6th, by which time the road surfaces were observed to be sensibly cooler.

(15) During the digging out operations, and the subsequent re-sealing of the affected
uncomfortable. Samples of the atmosphere from the general body of the air in No. 9 Top Level on the return side of the place where the heating was found did not, on analysis, give gaseous constituents of the character which might have been expected from heated ground of the intensity actually observed. The carbon monoxide content (0·0014-0·0036 per centum) was not unduly high for the Plodder Seam at Bickershaw.

(16) Although the management were convinced that the heated material had been successfully removed, the occurrence served as a warning that it was time for the No. 9 Face to be abandoned and stopped off.
were almost completed, and Mr. Lawson therefore decided to put in final stoppings.

(17) It is the usual practice in the Plodder Seam at Bickershaw to seal off abandoned panels by first building stoppings in the levels some 70 to 100 yards inbye of the main airway from which they were set out. Once the sealing of the panel has been completed, the remaining space outbye the stopping is then used for the intermittent stowing of waste dirt, with the result that the stoppings are gradually increased in thickness until they can be finally faced with a masonry wall alongside the main airway.

(18) It is also usual when ordinary stoppings have to be built for members of the Central Rescue Corps to assist. This course is taken, not as an emergency measure, but because these men are trained in the building of stoppings and their help usually results in the stoppings being built more quickly. Since their training takes account of fire and explosion risks, their procedure is always in accordance with these risks whether or not they are known to exist.

(19) The building of the stoppings in the two roads leading to No. 9 Face was begun on the morning shift of Friday, the 9th October, and work was continuous. In the Main Level, the place selected was 72 yards from the No. 9 Scouring at a point where the steel arched roadway was about 13 feet wide and 10 feet high. The stopping in the No. 9 Top Level was 64 yards from the Scouring where the roadway was from 5 feet to 7 feet wide and 3 feet to 3 feet 6 inches high. The stoppings were constructed mainly of bags of sand with some intermingling of bags of dirt filled on the spot. They were said to be re-inforced with old arches or rails or whatever else was handy, both at the inbye end and thoughout their length. During the erection of the stoppings the practice was adopted of leaving narrow tunnels about 3 feet square through the base of each stopping with the object of preserving some ventilation round No. 9 Face, until the sealing could be completed finally and quickly by plugging the tunnels simultaneously with further sand bags.

(20) Both stoppings were complete except for the sealing of the tunnels by about 10 a.m. on the 10th October, at which time the Top Level (return) stopping was 11 yards in length, and the Main Level (intake) stopping 8 yards in length. The final sealing of the tunnels was completed about mid-day: the intake at 12.15 p.m. and the return half an hour later.

(21) When both seals were completed, the separation doors in No. 9 Scouring between intake and return levels were opened to provide a free flow of air from the No. 1 Dip Face into the main return (No. 3 Brow). The immediate result of this was that for 64 yards of No. 9 Main Level, and for 53 yards of No. 9 Top Level there was no positive ventilation. This would not necessarily produce at once a vitiated, poisonous, or inflammable atmosphere at the face of the stoppings since all stoppings leak a bit at first, and there would still be a small flow of air through them if only because of a small pressure difference resulting from the difference in level of the two stoppings. For the two " blind " ends outbye the stoppings the manager had made provision for auxiliary ventilation by installing fans should their need arise. However other events supervened, and I do not think the operation of the fans would have changed the circumstances. However, as an aside, I feel it my duty to say that auxiliary ventilation should have been put into operation as a prudent measure against the accumulation of dangerous amounts of inflammable or noxious gases following the arrest of the main ventilation by the stoppings.

(22) The No. 9 Face, and parts of the two roads leading to it, were tbus finally sealed off almost two months after coal production ceased, and four days after the heating in the Top Level had been dealt with.

THE EXPLOSION

(23) At about mid-day on Saturday, the 10th October, when the stoppings against No. 9 East Face had been finally closed, the one on the intake was some few yards short of the usual minimum length of 11 yards put on when stoppings on old districts are first built. The manager therefore decided to continue with an afternoon shift of a small number of men to be engaged solely on the work of increasing the length of this stopping. The shift comprised two officials, two members of the Bootbstown Permanent Rescue Corps and nine other workmen.

(24) When the building of this stopping had first begun the belt conveyor originally in use for coal transport along No. 9 Main Level had been shortened to that place, and by running it in reverse direction it could be used for conveying sand bags from the No. 4 Brow Transfer Point to the stopping site.

(25) Some of the men on this afternoon shift were engaged in the actual building of the further length to the stopping: others in the transport of sand along the conveyor, and, farther outbye, others were preparing sand bags and taking them down the No. 4 Brow from the Loading Point to the Transfer Point at No. 9 East Main Level End. At about 4 p.m. there were five men near the face of the stopping: J. McLeod, the overman, F. B. Sargent, the deputy, J. Dawber and R. Evans, members of the Rescue Corps, and H. Tbomason, a haulage hand, while others were several yards away taking sand from the conveyor belt. The remainder of the men were distributed on various tasks between the Transfer Point and the No. 4 Brow Loading Point.

(26) While so engaged, the men at the Transfer Point heard a thud coming from the direction of the stopping, and on going through the separation doors on this road, they met a cloud of dust and fumes with some smell of burning. Eventually some men emerged from this, and soon it was realised that five men near the stopping had been overcome in some way as the result of some kind of explosion. Having first regained fresh air at the Transfer Point, the remaining group of men telephoned the surface while others reversed the conveyor belt so that the top belt travelled outbye, in the hope that someone disabled could perhaps make use of the belt to escape.

(27) The telephone message reached the manager, Mr. Lawson, at his home near the colliery. After making sure that the Permanent Rescue Corps had been summoned from the Boothstown Central Rescue Station ten miles away, he left for the colliery. By this time, Mr. Allison, the assistant manager, had gone underground.

(28) At approximately 4.25 p.m. a team of five rescue men from Boothstown went underground: they reached the No. 9 East by 4.50 p.m. travelling by foot down the No. 4 Brow (intake), meeting Mr. Allison on the way, and also passing two other men who had come from the affected

(29) By tbis time some of the smoke and dust had cleared and a fresh air base was set up at the entrance to No. 9 Main Level (transfer point). Arrangements were again made for the belt to be reversed, and the rescue brigade, wearing their apparatus, approached the Main Level stopping where they located tbe bodies of McLeod, Sargent, Dawber, Evans, and Thomason,

four of them together, and the other some few yards distant. All appeared unconscious or dead, and they were immediately taken to the fresh air base using the conveyor belt. On arrival there, artificial respiration was carried out in conjunction with the administration of oxygen but these measures proved unavailing. At 6 p.m. Mr. Bond, a Group Manager from a neighbouring group, Mr. Lawson, Manager, Mr. A. Cunliffe, Rescue Station Superintendent, and Dr. J. F. Erskine, Area Medical Officer, arrived together at the fresh air base where the doctor examined the bodies of the five men and pronounced them to be dead. Arrangements were then made for the transport of the bodies to the surface, and for the retreat of all persons from the seam.

(30) However, the atmosphere having cleared somewhat, the opportunity was taken by the Rescue Men to have a closer look at the stoppings. With their companions in support, W. Sturgeon, the Captain, went to the Main Level stopping and K. Shaw to the Top Level stopping. Approaching the Main Level stopping, Sturgeon observed that flame safety lamps, although extinguished, were still hanging from roof supports, and that hanging water bottles were undisturbed. These features indicated little violence. There was no flame to be seen, but at the stopping itself a hole was observed at the top about 3 feet wide and 1 foot in height, due, possibly, to the displacement of part of the top layer of sand bags. From the Top Level stopping, Shaw reported that no displacement had occurred, and again no sign of flame or smoke. On these occasions the opportunity was taken by these two men to collect a sample of atmosphere at the face of each stopping. On analysis the sample from the Main Level yielded among other gases, 0·016 per cent. of carbon monoxide and 0·46 per cent. of firedamp, while that from the return stopping was much more lethal with nearly 3 per cent. of carbon monoxide and 5 per cent. of firedamp.

(31) When all men had been accounted for, and these conditions confirmed, Mr. E. Small, Area Production Manager, who was then at the colliery, ordered a complete evacuation from the mine pending a decision on the next steps to be taken. All men were out by about 9 p.m. after an arduous journey with the bodies of the five men through the No. 4 Brow for about 2,000 yards against an average gradient of 1 in 8.

(32) Later, Mr. H. E. Clegg, Area General Manager, who was then at the colliery, having heard the principal facts of the occurrence, prudently decided that there should be no further exploration of the Plodder Seam because of the danger of a second explosion, and that permanent stoppings should be put in at the top of the three airways serving the seam. Even if the retention of some working area had been considered, it would have been impossible to build further stoppings without placing them so close to the others as to incur a grave danger from a subsequent explosion.

(33) The sites for the final stopping-off of the Plodder Seam were carefully selected, with the advice, among others, of Dr. H. L. Willett, Deputy Director-General of the Headquarters' Staff of the National Coal Board, who had been called to the colliery. It is not part of this report to recount this final work except to say that it was conducted under full emergency conditions with men underground only in sufficient numbers to secure the expeditious erection of the stoppings. The final closing of these stoppings was completed by 11 a.m. on Tuesday, the 13th October, and, after a suitably long waiting period with

no men in the mine, inspections were made of the stoppings periodically with sampling of the atmosphere behind them and tests for leakage. This was followed by further measures for strengthening them.

INVESTIGATION

(34) It was at once clear that an explosion had taken place within the area contained by the stoppings on No. 9 East Main Level and No. 9 East Top Level. No effects of violence had been observed except the displacement of part of the Main Level stopping; survivors had seen dust and smelled something burning, but had seen no flame. The deceased men had been overcome by carbon monoxide gas and their bodies showed no sign of burning or other external injury.

(35) When the two stoppings were first begun on Friday, the 9th October, there would be some immediate restriction of ventilation through No. 9 Face, and when they were finally plugged at about mid-day on the 10th, all ventilation would cease except for possible leakage through the stoppings. Now the estimated amount of 100 cubic feet of methane entering the air current per minute with normal ventilation might diminish with the cessation of ventilation but it would continue to be the main cause of change in the atmosphere within the stopped-off area. In fact with the completion of the seals the eventual production of an inflammable atmosphere was inevitable. Before such areas become sufficiently deprived of oxygen it can be assumed that the atmosphere, in its composition, passes through the inflammable range.

(36) When Mr. Lawson, the manager, decided to seal off No. 9 Face and roads, he was confident that the heated material found at the left hand side of No. 9 Top Level had been effectively dealt with. Samples of atmosphere from No. 9 Top Level continued to be taken until 7 a.m. on the 10th October, some 5½ hours before actual sealing took place. Although these samples were analysed for carbon monoxide alone the amount of this gas found was not abnormally high. In fact, over the whole period of 5th to 10th October, the average amount of this gas found here was 0·0022 per centum, the maximum, on one occasion only, being 0·0063 per centum. The site of the heating at the left hand side of No. 9 Top Level was last seen some four hours before actual sealing took place.

(37) There are, of course, other possible causes of ignition than spontaneous combustion. At the Inquest, the manager, Mr. Lawson, mentioned the possibility of frictional sparking occurring from a fall of material somewhere on the face or in the roads within the sealed area. Explosions of inflammable gas have been attributed to this cause, when in the absence of any more positive indication such falls of material have been identified with similarly positive evidence of where the ignition took place. I have also considered the question of sparking from electricity but the evidence of an electrician from Bickershaw was to the effect that all electric power to No. 9 Face was cut off on the 9th October, preparatory to the construction of the stoppings. After considering the remote possibility of frictional sparking I am bound to conclude that a much more likely source of ignition was the heating in No. 9 Top Level, and that the general confidence in the conditions there was misplaced.

(38) To support this conclusion it is necessary at this point to consider the experience with No. 8 Face, the one immediately to the rise side, and which

was worked before No. 9. This face had no experience of spontaneous combustion during its life: it was abandoned on 9th August, 1957, and stopped off on 11th November, 1957. Later the stoppings were gradually increased in length by the disposal of waste dirt. In July, 1959, samples taken on the No. 3 Brow on the return side of both No. 8 and No. 9 revealed an increase in the carbon monoxide content from about 0·002 to about 0·007 per centum. A closer search for the origin of this gas identified it with leakage out of No. 8 Main Level Stopping. Various attempts were made to improve the seal there, the main purpose being to reduce the amount of carbon monoxide on what was the main man-riding road, a concentration, which, although not dangerous, could not be tolerated. The measures adopted, which included the building of a brick wall as a face to the Main Level Stopping, were effective in reducing the amount of carbon monoxide reaching the No. 3 Brow.

(39) I am informed that when No. 8 Face was working it was customary to leave packing about 8 yards thick on the lower side of the Main Level. Between this pack and the coal rib side being formed by the advance of the face, a small airway was left so that air could circulate round the fast end. A continuous small airway of this kind which would in time become inaccessible could not be contemplated in a seam so liable to spontaneous combustion as the Plodder; consequently this small airway was cut off periodically by cross drivages through the pack about every 40 yards, the abandoned portion behind being then sealed. Now when No. 9 Face advanced later taking out all the coal, these small spaces, and the adjoining pack would be re-exposed, with the result that within a few yards of the left hand corner of No. 9 Face there would, temporarily, be only about 8 yards of packing separating No. 9 Top Level from what remained of No. 8 Main Level. Despite the thickness of stoppings at the outbye end of No. 8 Top and Main Levels, it is probable that small leakages of air occurred between No. 9 Face and No. 8 Face. A small pressure due to the ventilation causing such leakage would be assisted by the gradient, and by the high resistance of the outer part of the No. 9 Top Level which was the proper path of flow for the air. Small leakages of this kind are all that are needed to start spontaneous combustion: the air flow is insufficient to carry away the heat being generated so the temperature of the material rises continuously. One measure against such leakage through roadway packs is to raise the floor of the roadways by leaving down part of the face ripping until the floor level of the roadway being formed is above the roof plane of the coal extracted in working. This is a long established practice, in certain conditions, and could have been carried out in the Top Level of No. 9 Face where the Plodder Seam was being worked first over the immediately contiguous Haigh Yard seam. But in the converse case, which is sometimes adopted, of working the Haigh Yard first, the burying of packs in this way would be impracticable.

(40) While "digging out" operations were in progress at the heating in No. 9 Top Level, those engaged did not notice any movement of the air towards the abandoned No. 8 Face, but I feel that, having found distinctly hot material, and in the absence of any significant amount of carbon monoxide in the immediate atmosphere, the officials should have suspected that most of the products of combustion were in fact moving through the pack away from No. 9 and into No. 8 Face. Such movement would also seem to explain the observed rapid cooling of the road surfaces. It is possible that the heated material

dug out was only part of that actually raised to a high temperature, and that the remainder was still active behind the packing by which the roadway had been restored. The air leakage referred to, while feeding more oxygen to the fire, would also, because of its direction of flow, tend to conceal the real conditions from those working there. If some fire continued at this point, it is reasonable to assume that the accumulating firedamp in No. 9 Face, once the main stoppings were built, would first reach an inflammable or explosive concentration at the higher corner of the face and be ignited there. Although new packing had been inserted between any continuing fire in No. 8 and No. 9 Top Level, it would not be " flameproof ", and it is conceivable that the ignition of an explosive mixture first occurred in No. 8 Face and was propagated through the new packing into a larger accumulation of firedamp then present in No. 9.

(41) There is other and perhaps more reliable evidence that the signs first observed by the deputy Hodgson on the 4th October were indicative of only a fringe of what might have been a heating of fairly high intensity somewhere on the lower side of No. 8 Main Level. I have already referred to the detection in July last of excessive amounts of carbon monoxide from the stopping on No. 8 Main Level. While the leakage might have been due to expansion of residual gas under falling barometric pressure, it did in fact occur during periods of very stable pressure, and therefore is more likely to have been caused by leakage coming in from No. 9 Face under the influence of ventilating pressure and some buoyancy. Indeed it would seem that the progressive advance of No. 9 Face was to some degree *unsealing No. 8* or at least aggravating the leakage of air, and I can imagine a similarly progressive tendency to self-heating along the right hand side of No. 8 Main Level. If heating did occur it would probably be stifled by the consolidation of the packing as No. 9 Face advanced, and so I envisage the greatest intensity of heat, or tendency to self-heating would be just behind No. 9 Face. Once this face stopped, leakage would continue for some time at one place and the heating would grow in intensity until its effects began to be noticed within the No. 9 Face and were, of course, eventually detected by Hodgson on 4th October.

(42) There is further support for this view, but for this purpose I will have to digress on the question of analysis of the constituent gases in mine atmospheres, which has long been established as a reliable indication of the rate of oxidation (and of self-heating) of coal substance. With the oxidation of coal a variable amount of carbon dioxide and carbon monoxide is produced. With oxidation of coal at normal temperatures a very small quantity of these gases is produced in relation to the amount of oxygen absorbed. However T. F. Winmill and J. I. Graham* working together as long ago as 1915 found that the proportion of carbon monoxide varies more particularly with the temperature, and this gas is readily and conveniently determinable with modern apparatus in very small proportions, down to a few parts per million. Accordingly, spontaneous heating of coal substance is always associated with a rise in the ratio of carbon monoxide produced to oxygen absorbed usually expressed as a percentage, thus:—

$$\frac{\text{Carbon monoxide produced}}{\text{Oxygen absorbed}} \times 100$$

* Safety in Mines Research Establishment, Research Report No 142, " Research on Spontaneous Combustion of Coal in Mines—A Review. " H F. Coward. Page 52.

and Graham suggested this ratio as an indicator to be used in the early detection of heating. Its value is maintained even when the temperature continues to rise and actual fire results, though in open workings, with constant examination, other and more obvious signs will then have become evident. Since there is some very small amount of carbon monoxide produced with normal oxidation, the ratio as calculated will have a normal value for every seam, or group of workings, or for a mine, depending upon where the carbon monoxide present and the oxygen loss, respectively, are assessed: the indication of spontaneous heating lies in the rise of this ratio above what is known to be its normal value. From the experience of sampling over several years I am advised that the normal value of this ratio for the Plodder Seam at Bickershaw was 0·4 to 0·5 per centum.

(43) I have already mentioned in paragraph 38 the increase in carbon monoxide in the No. 3 Brow (return) which was later identified with an increase in the expulsion of this gas from behind the stoppings on No. 8 Face. Sampling of the atmosphere from inside these stoppings was also continued, and I would refer in particular to samples collected during the period 5th to 10th October, 1959, which are also typical of those collected earlier in August and September. The results range as follows:—

	Air content per cent.	Composition of air-free gas per cent.				CO/O_2 def. per cent.
		CH4	CO2	N2	CO	
No. 8 Top Level ...	2–10*	11–16	12–13	71–76	0·14–0·10	0·8–0·5
No. 8 Main Level ...	56–53	11–18	8–9	76–80	0·15–0·8	2–4·4

* With one exception (3 a.m. on the 7th) 28 per cent. air: possibly adventitious.

At first glance, the air content of these respective groups of samples might be accepted as not being abnormal for a sealed area presuming some inleakage of air through the Main Level stopping which was the original intake. However, the general composition of the samples does not support this. Those from the Top Level show a low carbon monoxide/oxygen ratio and a high carbon dioxide content, and therefore no evidence of heating but rather vitiation from ordinary oxidation. However, the samples from behind the Main Level stopping give a high carbon monoxide content (air free) and a high carbon monoxide/oxygen ratio, and are thus typical of an atmosphere on the return side of a serious heating. In the absence of any known heating near the No. 8 Main Level stopping itself (a possibility which cannot be ruled out) the atmosphere behind this stopping must be related to the known heating where No. 8 and No. 9 Faces joined. The continuance of an abnormally high carbon monoxide/oxygen ratio from the samples collected from behind No. 8 Main Level stopping after the heating in the left hand side of No. 9 Top Level had been dug out should have awakened some doubt of the complete efficacy of the measures there taken.

(44) I do not suggest that the reasoning I have employed should have occurred readily to the manager of the colliery and in fact there appears some little doubt of the reliability of the carbon monoxide/oxygen ratio when applied to stopped off areas, and this feature of its application is worthy of further investigation. Nevertheless, I think it reasonable to expect that the manager's

advisers, and in particular the Area Scientific Service, who were responsible for providing him with the analyses of the samples of atmosphere, might have shown more concern, and made a wider investigation of the series of results from No. 8.

(45) In justice to the management of Bickershaw, I must record that members of my staff,
N. Forster, H.M. District Inspector, were in close touch with the developments during the few days preceding the explosion. In fact, Mr. Forster visited the No. 9 Stoppings during the morning of the day of the explosion. These two Inspectors, from their own knowledge and observation, shared the confidence of the management that no active fire was being sealed off, but
were not aware of the character of the range of samples taken from behind No. 8 Stoppings which, as I have already suggested, was significant evidence of fire more deep seated in No. 8 Face than was suspected. However, in the light of subsequent and closer examination of the nature of these analyses from No. 8 Stoppings I am bound to conclude that fire existed somewhere in No. 8 Main Level, or adjacent thereto. This fire might not have been of large extent, but was probably of high intensity. Whether this was part of the fire found in No. 9 Left Hand, or another, is conjectural.

(46) In sealing off active fire there is a code of General Regulations first made in 1913, and now re-enacted under the Mines and Quarries Act, 1954, as the Coal and Other Mines (Fire and Rescue) Regulations, 1956. Among other things, these Regulations require the withdrawal of all persons from a mine during the process of sealing, or damming off, except those necessary to the work of building the stoppings. In addition to these Regulations there is an accepted code of safe practice within the coal mining industry based on a large amount of experience. In 1944 this experience was embodied in a Memorandum prepared by a Committee appointed by the Council of the Institution of Mining Engineers on "Sealing Off
randum, among other matters, dealt with the position leading up to the final sealing of stoppings already erected in part and, on sealing being completed, advised the withdrawal of all persons during a period of 24 hours. This time interval can only be an arbitrary one, but from the accumulated experience of the Committee it was felt that if in any circumstances an explosion inside the stoppings was to occur, it would come about well within that period. I feel sure that if Mr. Lawson, or the other members of the executive management at Bickershaw, had felt a remote possibility of fire continuing in the region of No. 9 left hand side, or No. 8 right hand side, the final sealing of the stoppings on the 10th October would have been conducted in accordance with the recommendations of the Memorandum, in which case no one would have been at risk when the explosion occurred.

(47) Another factor which must have contributed to the rate at which firedamp collected behind the stoppings on the No. 9 roadways was the fall in barometric pressure which began about 1 p.m. on Friday, the 9th October, after an unusually long period of stable pressure which accompanied the sumuner and autumn months of 1959. The fall of pressure continued into the 10th October (the day of the explosion); the maximum rate of fall was one of 2 millibars per hour during the four hours 12 noon to 4 p.m. This rate of fall,

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* Trans. Inst. Mining Engineers. Vol. CIII, Part 9.

though not abnormal, is quite appreciable, and would have a significant effect in producing an inflammable mixture in the sealed area at an earlier stage after the stoppings had been finally plugged. Bickershaw Colliery, amongst others in the North Western Division, receives warnings from the Meteorological Office of approaching severe barometric depressions, a service initiated by the National Coal Board as a measure of assistance to those in charge of gassy seams. It has been confirmed that such a signal was sent out by the Meteorological Office of an expected rapid rate of depression and was received at Bickershaw Colliery about 3 a.m. on the 10th October; but, both before the sealing of No. 9, and afterwards, this knowledge by the officials of a sharp fall of barometric pressure would not be expected, under the circumstances, to create any great anxiety in their minds about the conditions in the No. 9 area, unless they knew, or were suspicious, that material at high temperature was being sealed off. Without this knowledge, or suspicion, the precautions to be taken would consist simply of greater vigilance towards the appearance of inflammable or noxious gases near the stoppings at which men were working. The evidence I have heard is to the effect that the deceased officials, and the trained rescue men who were with them, had been constantly on the watch for such gases.

(48) In the described circumstances of an explosion behind stoppings which were largely left intact, and outside of which no flame was seen to pass by those who survived, I cannot be certain what part was played by coal dust in carrying the explosion towards the stoppings on No. 9 roadways. The No. 9 Main Level had been a coal transport road during the working period which ended on 14th August, 1959, and the manager, Mr. Lawson, stated that until that date a stone dust barrier erected in accordance with a National Coal Board internal Directive was in position about 200 yards from the face. However, Mr. Lawson recollects that after production ceased this barrier was removed so that the fittings could be used elsewhere in a productive unit. The volatile content of the Plodder Seam is 38·1 per cent. which, to comply with the Coal Mines (Precautions against Inflammable Dust) Regulations, 1956, requires the maintenance of at least 75 per cent. incombustible matter in admixture with the roadway dust when sampled in the prescribed manner. Samples of roadway dust were last collected from No. 9 Main Level and No. 9 Top Level in July, 1959. The records at the colliery show that the lowest proportion of incombustible matter found in the Main Level was 91·5 per cent. and in the Top Level, 89 per cent. These samples were collected some four weeks before coal production and transport ceased and therefore do not necessarily represent the conditions at the time of the explosion. It was stated by the manager, Mr. Lawson, that it was unlikely that any further inert dust treatment had been given to these roads after coal winning stopped on the 14th August, since the main production of coal dust would then cease.

(49) I therefore conclude that the explosion on the 10th October was mainly one of firedamp which inevitably collected on the No. 9 Face and in the Main and Top Levels when the stoppings on these latter two roads were finally plugged and sealed. The firedamp would probably reach inflammable proportion first in the top corner of No. 9 Face adjacent to where I think spontaneous combustion persisted. I believe the firedamp was there ignited by some heated material lying possibly within the old right hand packing of No. 8 Face just beyond the reach of the excavation carried out at that point

on 4th and 5th October. I think that the danger of explosion following sealing was accentuated by the rapid fall of barometric pressure experienced before and during sealing. Having in mind the character of No. 9 Main Level as a coal transport road, it is possible that coal dust played some part in propagating the explosion towards the Main Level stopping.

(50) Before concluding this report I would place on record my appreciation of the exemplary behaviour of all persons in the neighbourhood of the stoppings when the explosion occurred. Everyone seems to have acted with immediate concern for the safety of the five men near the Main Level stopping, and in particular, the act of putting the roadway conveyor into its normal running direction (top belt moving outbye) was a resourceful move made in the hope that some survivor would not be too disabled to use this means of getting to safety. That it was unavailing does not detract from the inspiration which prompted it. I would especially mention the two members of the Permanent Rescue Corps, W. Sturgeon, and K. Shaw, who, with their supporting brigade companions, made necessarily brief but observant examinations of the two stoppings after the explosion. They, above all, from their training and experience, would be aware of the danger of a second explosion, and their subsequent reports of the condition of the stoppings and the information that no fire existed in the open roads outside provided a valuable and comforting reassurance to all concerned with the remaining operation of sealing off the Plodder Seam.

RECOMMENDATIONS

In summarising comment I have made in parts of this report, I make the following recommendations:—

(1) I understand that the Council of the Institution of Mining Engineers have appointed a small Committee to revise the Memorandum "Sealing Off Fires Underground" originally published in 1944 and referred to in paragraph 46 of this report. Although the point may not strictly be within the terms of reference of this Committee, I think it should consider, concurrently with other related matters, the value to be attached to the relationship between carbon monoxide produced and oxygen absorbed, and, indeed, any other relationship between constituent gases, found in samples of atmosphere taken from behind stoppings as indications of continuing fire or of the progress of spontaneous combustion (Paragraph 44).

(2) Where, with longwall working in seams liable to spontaneous combustion it is the practice for successively worked faces to strip the goaf edges of previous workings already stopped off, further measures should be considered with a view to minimising leakage between a working area and a sealed one. In this connection the already common practice of burying packs should be extended. In addition, sand packing should be inserted alongside coal ribs, especially where these will be subsequently taken out by a succeeding working (Paragraph 39).

(3) In all cases, the time which elapses between a working face ceasing production and its final isolation with explosion proof stoppings should be as short as possible compatible with the recovery of valuable machinery and materials.

(4) Since the danger of an inflammable atmosphere can arise in any area or workings to be sealed as soon as the ventilation is reduced in amount by the beginning of the stoppings, their completion to an explosion proof condition should be effected as quickly as possible, whether fire is present or not. Consequently, in seams liable to spontaneous combustion I recommend that sites for stoppings should be selected and some preparatory work done while the unit is still in production. In fact, in some seams where spontaneous heating is frequent, such preparatory work has been traditional practice.

ACKNOWLEDGMENTS

I would thank the representatives of all organisations who assisted in the investigation of the explosion, particularly Mr. Lawson, the manager, and other members of the immediate management of Bickershaw Colliery who unreservedly put at my disposal all information relating to conditions in the Plodder Seam which I considered pertinent to the investigation. I must also thank Mr. F. J. Hartwell, O.B.E., and Dr. F. V. Tideswell, O.B.E., of the Safety in Mines Research Establishment of this Ministry for their assistance with the interpretation of samples of mine atmospheres, and for similar consultation with Mr. N. Simpkin, Deputy Chief Scientist, North Western Division, National Coal Board, and Mr. S. V. Wild, Chief Scientist of the No. 2 (Wigan) Area.

To Mr. G. M. Smith, Group Surveyor of the No. 2 (Wigan) Area, I am indebted for the preparation of the plan and section which illustrates this report.

I have the honour to be, Sir,

Your Obedient Servant,

R. H. CLOUGH.

APPENDIX

NAMES OF THE MEN KILLED IN THE EXPLOSION

Name	*Age*	*Occupation*
John McLeod	28	Overman
Frederick Brian Sargent ...	27	Deputy
Henry Thomason	48	Haulage hand
Jeremiah Dawber	39	Member of Permanent Rescue Corps
Reginald Evans	38	Member of Permanent Rescue Corps

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